Determination of the Most Economical Nursery Feeding Regimen for Pigs Fed from Weaning to Market Weight

Rebecca L. Harris

Advisor: Dr. Keith Irvin

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Examination Committee: Dr. Keith Irvin
Dr. Ray Miller
Dr. Steven Moeller

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Rebecca L. Harris
Department of Animal Sciences, The Ohio State University Columbus, 43210

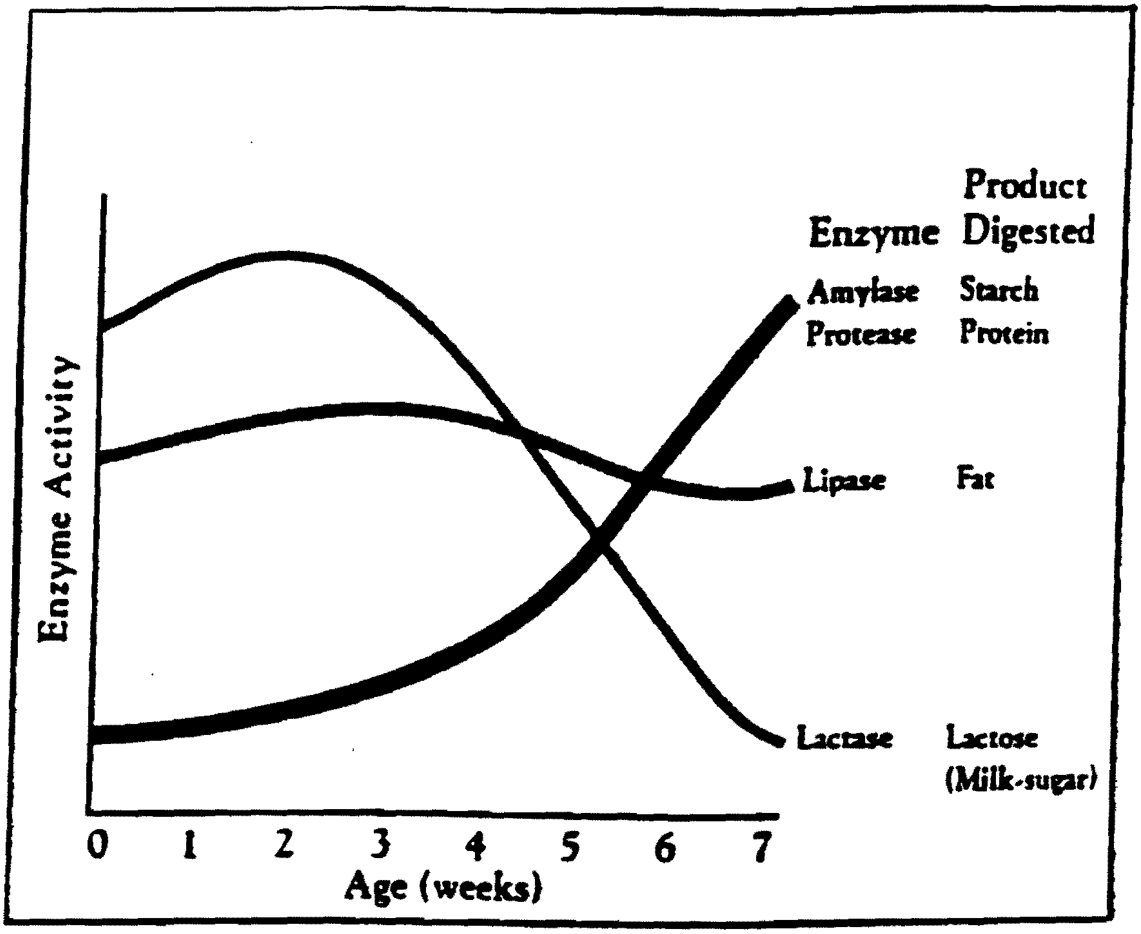
Abstract

Feed consumption and gain were measured to examine the performance of pigs fed either a simple diet sequence in the nursery phase (control group) or a complex diet sequence in the nursery phase (treatment group). Pigs weaned at 18 $\pm$ 2 days were randomly assigned by weight to nursery pens. The simple diet sequence consisted of two diets. The simple diet sequence consisted of diets containing mostly soybean meal and corn, the first diet contained dried whey. The complex diet sequence consisted of three diets. The first diet had spray-dried porcine plasma, lactose, and dried whey. The second and third diets were the diets used for the control group. The treatment group had higher average daily gains (ADG) during the first two weeks of the nursery phase ($P<.01$). There was no overall significant difference in the nursery, grower, or finisher phase for ADG. Feed efficiency was significantly better in the nursery phase for pigs in the treatment group ($P<.01$). There was no significant difference in feed efficiency between the control group and the treatment group in the grower phase. The control group tended to have better feed efficiency in the finishing phase ($P=.28$). There was no significant difference in feed intake between the treatment and control group in the nursery, grower, or finisher phase, although feed intake tended to be higher in the control group in the grower phase (P=.18). Backfat was significantly higher in the treatment group at termination of the test (P=.03). The average cost to feed a pig in either group on an ingredient basis was the same. On a commercial basis it costs more to feed the pigs in the treatment group. Mortality was higher in the control group. Pigs do better when fed a complex diet sequence in the nursery phase because mortality is lower. It is economical to feed pigs a complex diet sequence in the nursery phase.

Introduction

Feed represents 60-75% of the cost of producing hogs. Simple nursery diets are diets that contain mostly corn, soybean meal, and dried whey. Feeding simple diet sequences in nursery pigs would decrease feed costs, but adding milk products to simple diets increases digestibility of energy and protein (Cline, 1992), thus increasing growth performance. Complex diets contain more digestible carbohydrate and protein sources, such as lactose and casein that is found in milk. Porcine plasma has recently been considered as an alternative to milk products because the quantity of milk products available to the feed industry is decreasing. Porcine plasma contains 68% protein and 6.1% lysine (Goodband, et al., 1993). One theory on how plasma improves piglet performance is that the plasma enhances the pig's immune system in an unknown way (Nutrition Digest, 1995). According to research by Ermer, et al. (1994), porcine plasma increases palatability. Feeding complex diets have been found to increase feed intake and improve growth of weaned pigs (Graham et al., 1981).

The newly weaned pig is better able to digest milk products than nutrients from other sources, especially plants (Cline, 1992). Milk products improve performance because, in the first 5-6 weeks of a pig's life, the enzyme lactase, which breaks down lactose, or milk sugar, is present in higher concentrations than amylase and protease. Amylase breaks down starch and protease breaks down proteins. Lactase activity peaks at approximately two weeks of a pig's life then it gradually decreases until approximately week seven where it levels off. Lipase, the enzyme which breaks down fat has no significant fluctuations from weeks 0-7 of a pig's life (Fig. 1.). It is thought that lipase's activity increases rapidly after birth and remains high (Bryant and Hayden, 1993). Pigs adjust to plant material within 1-2 weeks postweaning (Cline, 1992). During this two week period the enzymes amylase and protease are increasing, resulting in an increased ability of the pig to digest the starch and protein components in plant material. Leibholz (1982) found that the digestibility of milk proteins by young pigs was greater than that of other protein sources. The improvement in performance of early weaned pigs fed diets containing milk products is apparently due to the ability of the young pig to utilize the carbohydrate and protein components from milk more effectively than those components from plant feed ingredients (Turlington et al., 1989). Giesting et al. (1985) indicated that the carbohydrates and protein components of skim milk had an additive effect on the performance of starter pigs.



Source: Designing a Pig Starter Feeding Program, K. L. Bryant and K. H. Haydon, Carl S. Akey, Inc.

Fig. 1. Digestive enzyme activity pattern in young swine.

Tokach et al. (1989) found further evidence that milk products improve performance and nutrient digestibility in 3-week-old pigs.

Today it is common to feed nursery pigs in three phases. Kansas State University devised a three phase program which was designed primarily to gradually convert the piglet from a high fat, high lactose, liquid diet, to a low fat, low lactose, high carbohydrate, dry diet (Goodband, et al., 1993) Phase 1 and phase 2 diets are used primarily to get the pig to start eating dry feed. The ingredients are usually highly palatable, highly digestible products such as dried skim milk. The phase 3 diet does not have the highly palatable, expensive ingredients, so it is more economical (Goodband, et al., 1993). Results from research at Kansas State University have shown that spray dried protein plasma and lactose can effectively replace the milk products in phase 1 and phase 2 diets. In research by Goodband, et al. (1993) pigs fed diets containing spray dried protein plasma gained 30% faster and consumed 20% more feed then pigs fed a diet with skim milk or whey.

Complex diet sequences cost more than simple diet sequences; however, many swine producers feed complex diet sequences to maximize growth performance without regard to the economics involved. Therefore, the question is whether or not the improved performance of nursery-aged pigs fed complex diet sequences, compared with a simple diet sequence, can justify the increased costs associated with feeding complex diet sequences. The purpose of this research was to determine whether the increased costs associated with feeding complex diet sequences in nursery-aged pigs are justified by the improved feed efficiency and an increased rate of gain in the pigs fed the complex diet sequence.

The first objective of this research was to compare growth performance (average daily gain and feed efficiency) of 18 ± 2 day old pigs fed either a simple diet sequence or a complex diet sequence in the nursery. The second objective was to determine if the differences in pigs' growth performance during the nursery period would result in differences at market weight (105 kg). The final objective was to determine from two diet sequences, which one is the most economical nursery feeding regimen for pigs being fed from weaning to market weight.

Materials and Methods

Population and sample. The population was 150 crossbred pigs that were weaned at 18 ± 2 days. The average weight of the pigs was 5.59 kg. Healthy pigs were randomly assigned by weight. There were six pigs per nursery pen, 25 pens were used. Barrows and gilts were equalized where possible. There were five pigs that died in the nursery and one removed from the test. The remaining 144 pigs were moved into the grower/finisher with 22 ± 2 pigs per pen. The nursery pens were randomly assigned within treatment groups, to a pen in the grower/finisher. There were 6 grower/finisher pens used, 3 pens per treatment.

Procedure and Data Collection. Each nursery pen was assigned to one of two diet sequences. The simple diet sequence (control) was as follows: Diet 1 (Table 1, diet 1) was fed until the average weight of the pigs in the pen was 11.5 kg ± 1 kg. The second simple diet (Table 1, diet 2) was implemented when the pigs in the pen weighed an average of 11.5 kg ± 1 kg. The pigs remained on this diet until

Table 1. Diet composition (%) of nursery diets.

Ingredient	Diet 1[a]	Diet 2[b]
Ground corn	48.85	67.08
Soybean meal, 44% CP	25.95	28.75
Edible dried whey	15.00	-----
Fish meal	4.00	-----
Fat (stabilized)	3.00	-----
Ground limestone	0.45	0.82
Dicalcium phosphate	0.90	1.50
SW -Premix 300	0.30	0.30
TMS - 50	0.50	0.50
Copper sulfate	0.05	0.05
Mecadox	1.00	1.00
Nutrient	**Calculated composition (%)**	
Lysine	1.20	1.00
Protein	20.00	18.30
Calcium	0.80	0.75
Phosphorus	0.70	0.65

[a] First diet in simple diet sequence (weaning - 11.5 kg)
Second diet in complex diet sequence (11.5 kg-23.0 kg)

[b] Second diet in simple diet sequence (9.0 kg-13.5 kg)
Third diet in complex diet sequence (13.5 kg-23.0 kg)

the average weight of the pigs in the pen was 23 kg ± 1 kg, at which time they were moved into the grower/finisher. The complex diet sequence (treatment) was as follows: The first diet used (Table 2) was fed until the average pig weight in the pen was 9 kg ± 1 kg. Diet 2 (Table 1, diet 1) was fed until the average weight of the pigs in the pen was 13.5 kg ± 1 kg, and diet 3 (Table 1, diet 2) was fed until the average weight of the pigs in the pen was 23 kg ± 1 kg. The pigs were then moved into the grower/finisher. Five of the grower/finisher pens resulted from four nursery pens each with the same diet sequence. The sixth grower/finisher pen resulted from five nursery pens with the same diet sequence. All of the pigs in the nursery were vaccinated for erysipelas. In addition there were four pigs that were afflicted with greasy pig disease. There were two pigs from each treatment that were affected. Each of these pigs was treated with either Baytril, Naxel, Lincomix, or Tylan. After a short trial period, one of the pigs was sent to the USDA Lab for diagnostic tests and the remaining three were treated with Lincomix. These pigs recovered and remained on test.

The grower diet and the finishing diet (Table 3) were the same for all the pens, regardless of the nursery diet sequence they received. The grower diet was fed until the pigs in the pen averaged 64 kg ± 4.5 kg. The test was terminated when the pigs in the pen weighed an average of 100 kg ± 4.5 kg. The pigs were fed ad libitum during the entire test period. All of the feed used was pelleted. If a pig lost weight in two consecutive two week periods in the grower or finisher they were terminated from the experiment.

Table 2. Diet composition (%) of nursery diet containing plasma.[a]

Ingredient	%
Corn	39.32
Soybean meal, 44% CP	16.90
SDPP[b]	8.50
Whey, dried	20.00
Lactose	10.00
Soybean oil	3.00
Dicalcium phosphate	1.00
SW - Premix 300	0.30
DL - Methionine	0.13
TMS - 50	0.50
Copper Sulfate	0.10
Mecadox	0.25
Selenium	0.30 ppm

Nutrient	Calculated Composition
ME, Kcal/lb	1592.00
Crude protein, %	19.30
Lysine, %	1.29
Calcium, %	0.81
Phosphorus, %	0.68
Sodium, %	0.79

[a] First diet in the complex diet sequence (weaning-9.0 kg)

[b] SDPP is spray-dried porcine plasma

Table 3. Diet composition of grower/ finisher diets (%)

Ingredient	Grower	Finisher
Ground corn	75.70	81.69
Soybean meal, 44% CP	21.50	15.73
Ground Limestone	0.90	0.86
Dicalcium phosphate	1.10	0.92
SW - Premix 300	0.30	0.30
TMS - 50	0.50	0.50
Nutrient	Calculated composition (%)	
Lysine	0.80	0.65
Protein	16.00	14.00
Calcium	0.65	0.60
Phosphorus	0.55	0.50

The pigs were weighed weekly in the nursery and every two weeks in the grower/finisher. The experimental period for the nursery phase was one week. The experimental period for the grower and finisher was two weeks. Backfat was measured at the 10^{th} rib using ultrasound at the termination of the test. This was used to determine if the nursery diets affected body composition.

Feed samples were taken from each nursery diet. A total feed analysis was done on each sample (Tables 4,5,6) at the Research Extension Analytical Laboratory at Wooster, OH. Each addition of feed was weighed. Feed remaining at the end of each week in the nursery, every two weeks in the grower/finisher, and at the end of a feeding phase was weighed to determine intake.

Data Analysis. The data analysis used was the ANOVA procedure of SAS on a personal computer. The design used was a randomized complete block.

Results and Discussion

Average daily gain data. As can be seen by the average daily gain data per period in figure 2 and table 7, the animals receiving the complex diet sequence had significantly better average daily gain in periods one and two ($p<.01$) than the control group. This was expected because the porcine plasma, whey, and lactose present in the first diet of the complex diet sequence are highly digestible and easily absorbed in the pig's intestine at weaning. These results are similar to results by Goodband, et al. (1993). In their research, pigs fed diets containing spray dried porcine plasma gained 30% faster ($P<.05$) during the 0 to 2 week period post weaning than pigs fed a diet containing dried whey. There were no

Table 4. Analysis of First simple diet, second diet in complex diet sequence (table 1, diet 1) on an as fed basis.[a]

Ingredient	%
Dry matter	91.90
Crude protein	22.60
Phosphorus	0.69
Potassium	1.03
Calcium	0.91
Magnesium	0.15
Sulfur	0.28[b]

Ingredient	Parts per million
Manganese	259.00
Iron	518.00
Copper	251.00
Zinc	326.00

[a] Analysis done at the Research Extension Analytical Laboratory, The Ohio State University, Wooster, OH.

[b] Not analyzed, value is estimated

Table 5. Analysis of Second simple diet, third diet in complex diet sequence (table 1, diet 2) on an as fed basis.[a]

Ingredient	%
Dry matter	89.50
Crude protein	18.10
Phosphorus	0.61
Potassium	0.72
Calcium	1.21
Magnesium	0.15
Sulfur	0.27[b]
Ingredient	**Parts per million**
Manganese	38.00
Iron	473.00
Copper	160.00
Zinc	147.00

[a] Analysis done at the Research Extension Analytical Laboratory, The Ohio State University, Wooster, OH.

[b] Not analyzed, value is estimated

Table 6. Analysis of plasma diet (table 2) on an as fed basis.[a]

Ingredients	%
Dry matter	91.60
Crude protein	19.90
Phosphorus	0.63
Potassium	0.85
Calcium	1.05
Magnesium	0.12
Sulfur	0.27[b]
Ingredients	**Parts per million**
Manganese	41.00
Iron	348.00
Copper	275.00
Zinc	115.00

[a] Analysis done at the Research Extension Analytical Laboratory, The Ohio State University, Wooster, OH.

[b] Not analyzed, value is estimated

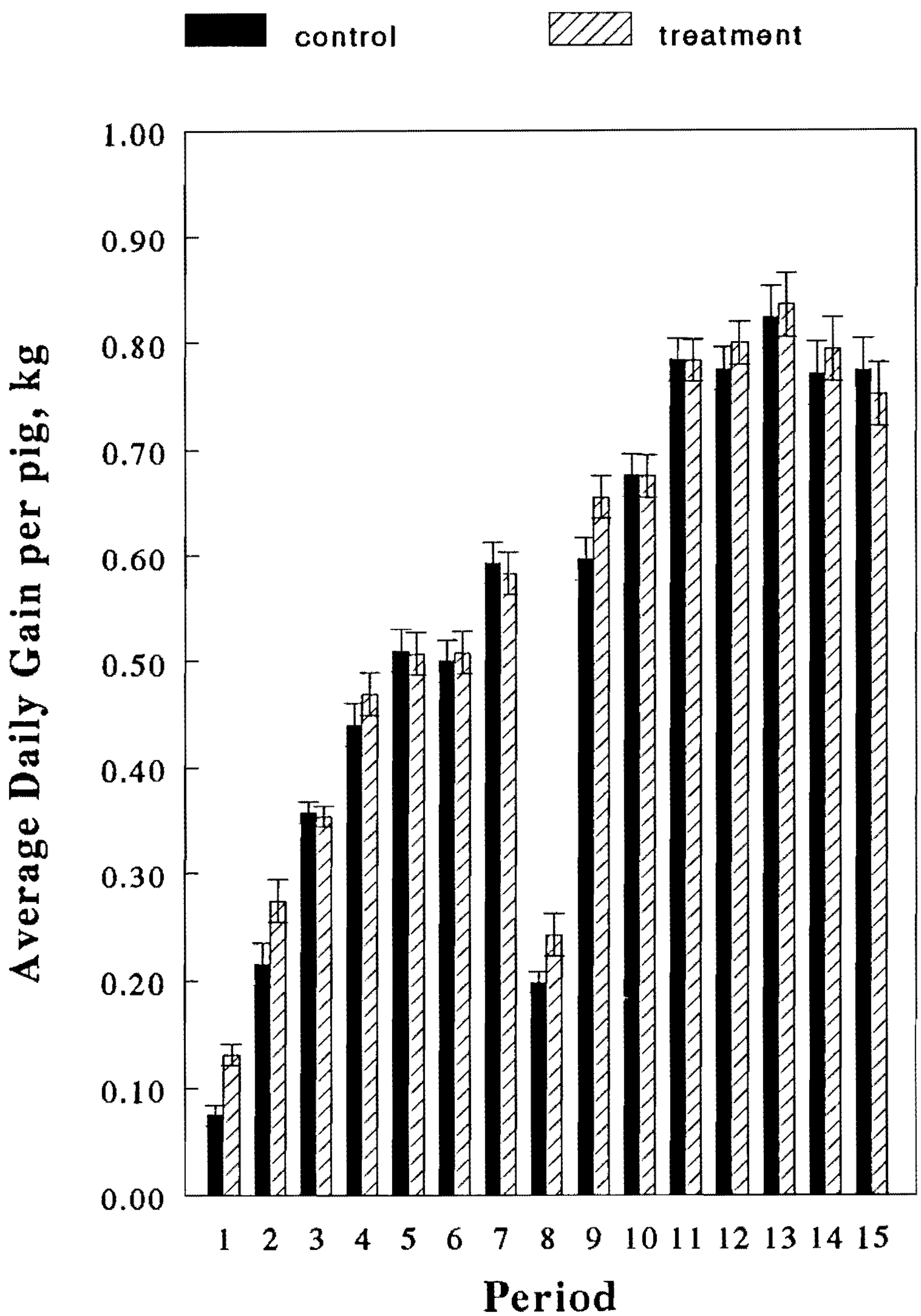


Fig. 2. Average daily gain by period of the control group and the treatment group from weaning to market weight.

Table 7. Average daily gains of control group and treatment group per period in the nursery phase.[a]

PERIOD	CONTROL	S.E.[b]	TREATMENT	S.E.	P VALUE[c]
1	0.075	.01	0.131	.01	<.01
2	0.215	.02	0.274	.02	<.01
3	0.358	.01	0.354	.01	0.86
4	0.440	.02	0.469	.02	0.29
5	0.510	.02	0.507	.02	0.89
6	0.500	.02	0.508	.02	0.82
7	0.593	.02	0.583	.02	0.73
8	0.198	.01	0.242	.02	0.11
9	0.597	.02	0.655	.02	0.09
10	0.676	.02	0.675	.02	0.97
11	0.784	.02	0.783	.02	0.98
12	0.775	.02	0.799	.02	0.46
13	0.823	.03	0.835	.03	0.79
14	0.771	.03	0.798	.03	0.49
15	0.774	.03	0.751	.03	0.87

[a] A period was one week long.

[b] Standard error of deviation, rounded to the hundredth place.

[c] P values rounded to the hundredth place.

significant differences between the treatment group and control group for average daily gain from period three to period nine (P>.10). These results can be explained by the increase in amylase concentrations in the digestive system, in conjunction with the decrease of lactase (fig.1). The treatment group exhibited a trend of better gains than the control group in period eight (P=.11). In period nine the treatment group did significantly better (P=.09) than the control group. There is no known explanation for this difference since both treatments were on the same diet during periods eight and nine. Period eight was the first period of the grower phase, the differences may have resulted from the ability of the pigs fed a complex diet sequence in the nursery to adjust better to a change in diet and environment. One theory on how plasma increases performance is that it enhances the pig's immune system (Nutrition Digest, 1995). If this is found to be true, then this may explain why pigs fed a diet containing porcine plasma in the nursery phase adjusts better to diet and environment when moved to the grower and fed a different diet. More research into the reason for the improved gains at the beginning of the grower phase needs to be done.

Figure 3 illustrates the average daily gains of the treatment and control group during the nursery, grower, and finisher phases. There were no significant differences in average daily gain in the nursery, grower, or finisher phases between the treatment group and the control group. These results indicate that the significantly higher average daily gains in periods 1, 2, and 9 exhibited by the pigs fed the complex diet sequence in the nursery phase did not

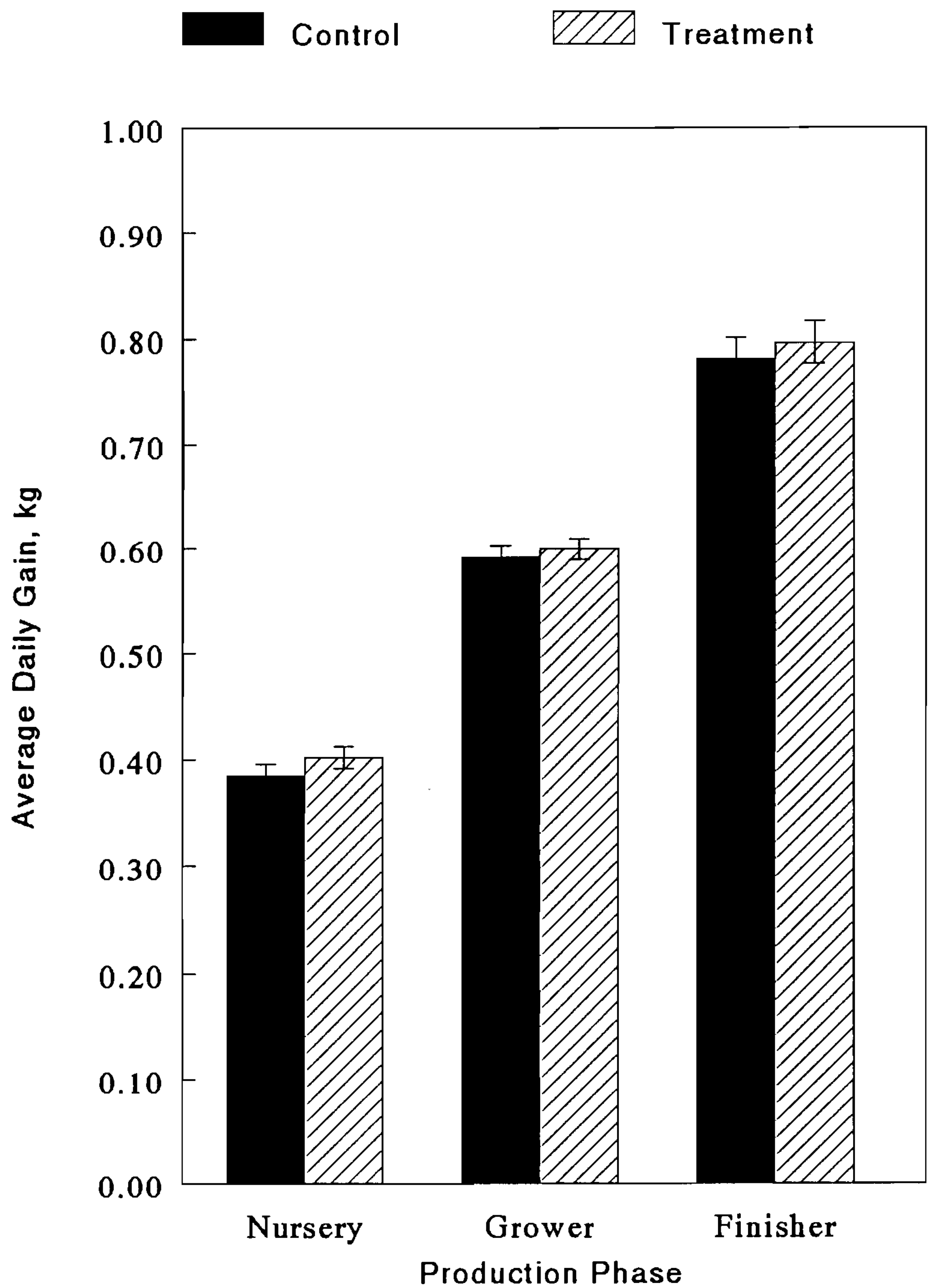


Fig. 3. Average daily gain of the control group and the treatment group in the nursery phase, the grower phase, and the finisher phase.

carry through the entire production phase. After period two, gains were not significantly different until the pigs were moved into the grower. It is hypothesized that the pig's digestive system in the control group had adjusted to the lower quality diet and had become more able to digest plant material and therefore absorb more nutrients and achieve similar gains to those pigs fed the complex diet sequence. After the first two to three weeks postweaning, lactase has decreased and amylase has increased. The pigs fed the complex diet sequence would have been fed the second diet in the sequence, which does not contain porcine plasma or lactose. This may have resulted in the differences in gain in the nursery phase not to be statistically significant. In the grower and finisher phases there were only one period (9) where there was a significant difference in gains. There was no significant difference in gain in the grower and finisher phase. This was probably due to the treatment group and the control group being fed the same diet.

Feed efficiency data. Feed efficiency data can be seen in figure 4 and in table 8. Feed efficiency was significantly better in the treatment group during the nursery phase ($P<.01$). Feed efficiency was probably better in the treatment group because the pig's digestive system is more able to digest and absorb the porcine plasma, lactose, and whey diet fed to the treatment group during this time period. If the nutrients are more readily digested and absorbed, the pig does not need to consume as much feed to have the same amount of gain than if the diet was less digestible. Feed efficiency was not significantly different between the treatment group and the control group in the grower phase. In the finisher

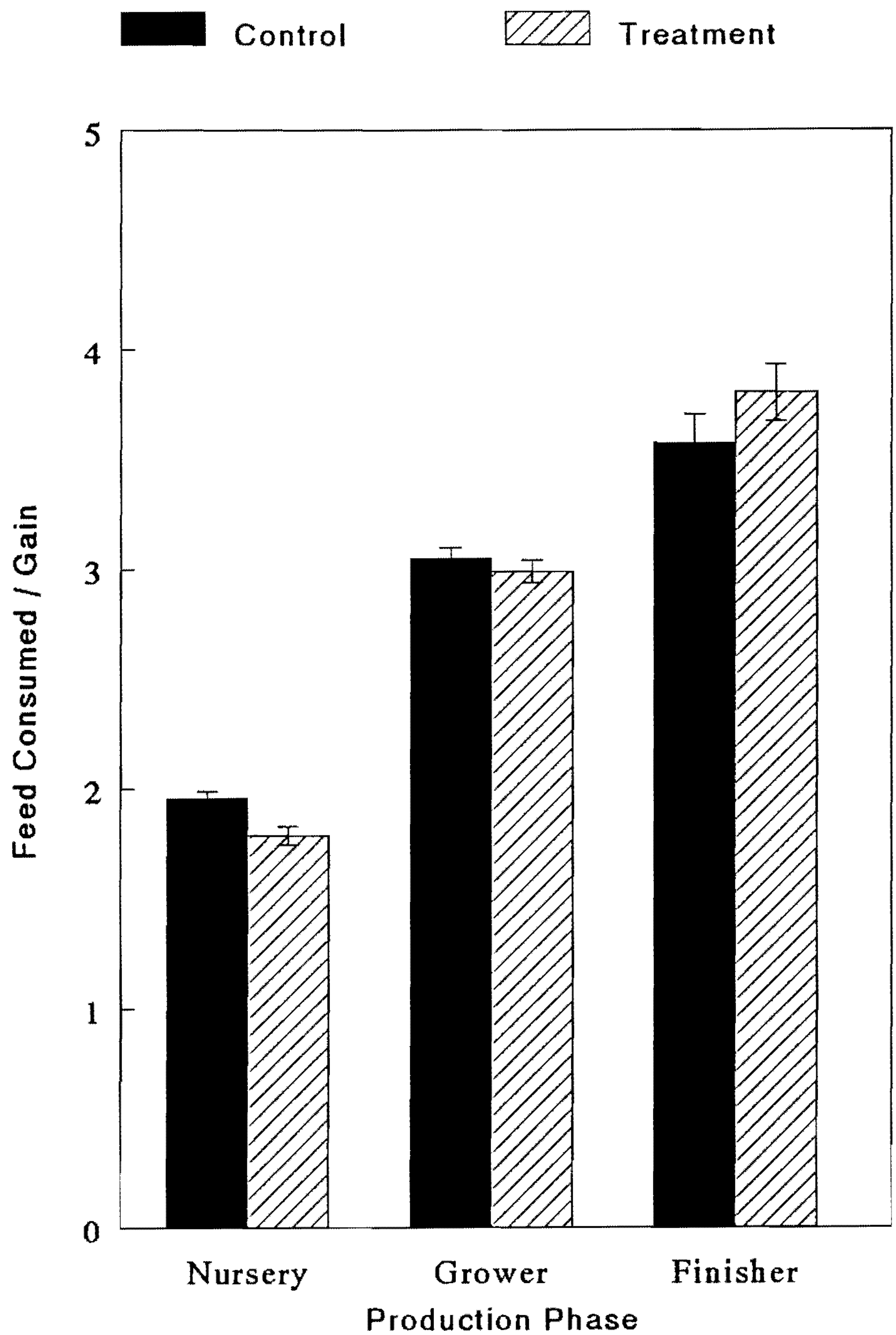


Fig. 4. Feed efficiency of the control group and the treatment group during the nursery phase, the grower phase, and the finisher phase.

Table 8. Feed Efficiency for each production phase.[a]

NURSERY

	Control	Treatment
Feed Efficiency	1.96	1.79
Standard error[b]	0.03	0.04
P value[c]	<0.01	

GROWER

	Control	Treatment
Feed Efficiency	3.05	2.99
Standard error	0.05	0.05
P value	0.42	

FINISHER

	Control	Treatment
Feed Efficiency	3.57	3.80
Standard error	0.13	0.13
P value	0.28	

[a] Feed Efficiency = kg. feed consumed / kg. of gain

[b] Standard error rounded to the hundredth place

[c] P value rounded to the hundredth place

phase, feed efficiency tended to be better in the control group (P=.28).

Feed consumption data. Feed intake per pig per day results can be seen in figure 5 and table 9. Feed intake was not significantly different between the control group and the treatment group during the nursery phase. This was not expected because in research done by Ermer, et al. (1994) pigs fed a diet containing porcine plasma ate more than pigs fed a diet containing skim milk (P<.01). Therefore, the pigs on the complex diet should have consumed more feed in the nursery phase due to the palatability of the first diet they were fed. Pigs fed the complex diet sequence tended to consume more feed in the grower phase (P=.18) than did the pigs fed the simple diet sequence in the nursery. Feed intake was not significantly different between the treatment group and the control group in the finisher phase.

Mortality. Mortality rate was 5% in the control group and 1% in the treatment group during the nursery phase. In the grower, mortality was 4% in the control group and 1% in the treatment group. In the finisher, mortality was 1% in the control group and 1% in the treatment group. One pig would have been removed from test in the treatment group on the last day. If that pig would have been counted in the pigs taken off test, mortality would have been 3% for the treatment group in the finisher. In research by Whang and Easter (1995), morbidity was found to be lower in pigs fed a three-phase diet that included dried skim milk, dried whey, lactose, and porcine plasma than in pigs fed a single phase soybean-based diet in the nursery phase.

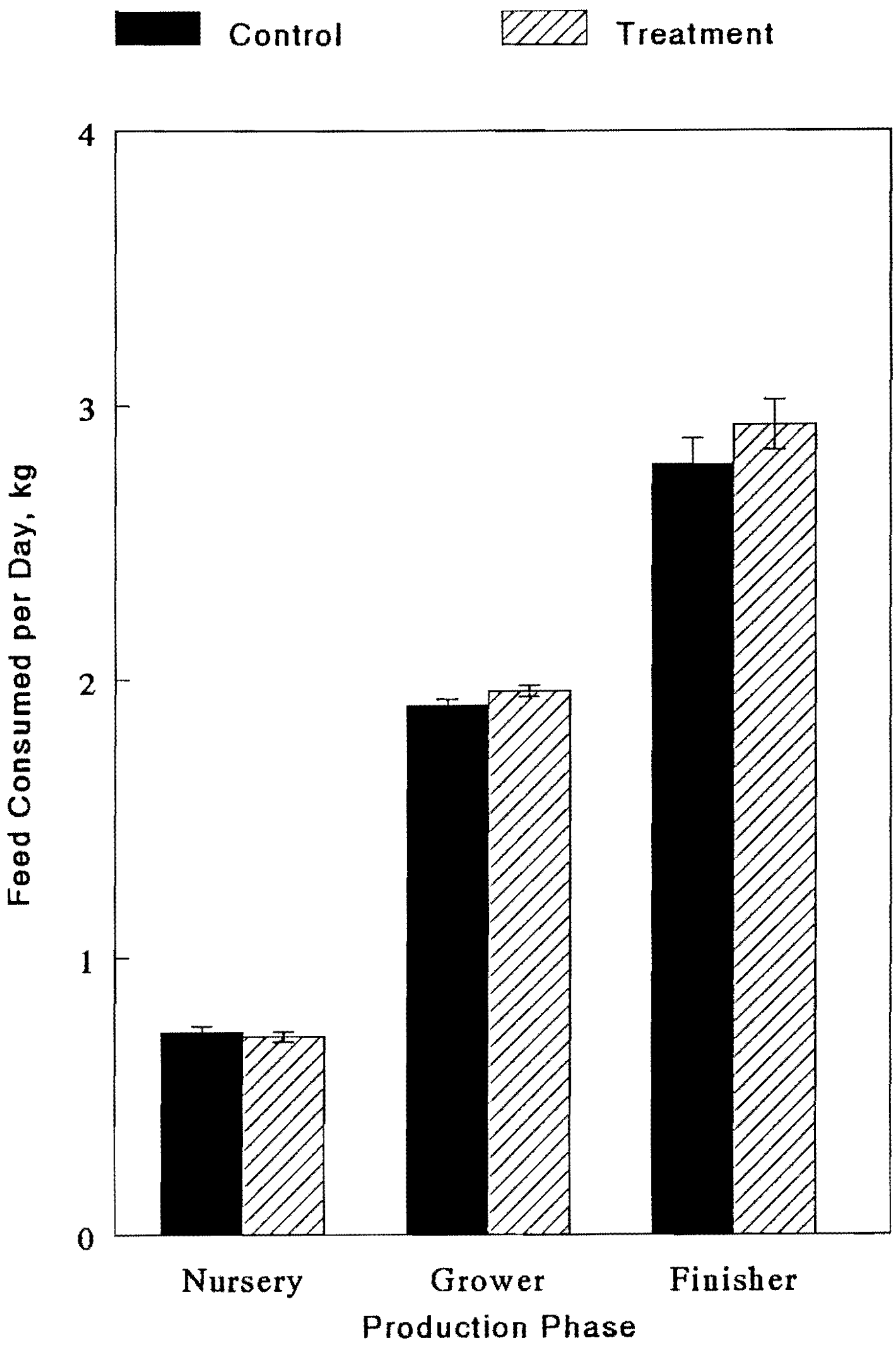


Fig. 5. Feed intake per pig in the control group and the treatment group during the nursery phase, the grower phase, and the finisher phase.

Table 9. Feed Intake per pig per day for each production phase.

NURSERY

	Control	Treatment
Feed Intake	0.73	0.71
Standard error[a]	0.02	0.02
P value[b]	0.35	

GROWER

	Control	Treatment
Feed Intake	1.91	1.96
Standard error	0.02	0.02
P value	0.18	

FINISHER

	Control	Treatment
Feed Intake	2.79	2.93
Standard error	0.09	0.09
P value	0.31	

[a] Standard error rounded to the hundredth place

[b] P value rounded to the hundredth place

Performance data may be biased in the grower and the finisher due to health problems. There was severe tail biting (25% of the pigs in the pen) in one of the control pens and there were several other isolated cases in the remaining pens, both control and treatment groups. The test was originally supposed to be terminated when the average weight of the pigs was 105 $\pm$ 4.5 kg, but the termination weight was changed to 100 $\pm$ 4.5 kg due to poor performance of two control pens and one treatment pen. The pigs in these pens had pneumonia. They were treated with antibiotics, but they continued to perform poorly. The pneumonia may have been caused by a sudden drop in temperature, or another environmental factor. The fact that two control pens were affected and one treatment pen was affected may have been due in part to a more ineffective immune system in the control pigs, but this is not known.

Body Composition. Tenth rib backfat thickness was measured at termination of the test, (table 10). The control group had significantly lower backfat thickness than the treatment group (P=.03). Since the treatment group gained more in the first two periods, it may be possible that they gained fat and the control group was leaner going into the grower phase and continued to be leaner.

Economics. The costs of the diets are compared on an ingredient and commercial price basis in table 11. On an ingredient basis, the pigs fed a simple diet sequence in the nursery and the pigs fed a complex diet sequence in the nursery cost the same to feed on an average cost per pig per day during the test period. The average

Table 10. Backfat thickness taken at the 10^{th} rib.

	Backfat thickness (mm)	Standard error
Control	18.37	0.57
Treatment	20.16	0.57
P value	0.03	

Table 11. Feed cost per pig per day from weaning to termination.

Ingredient Basis

Nursery

	Control	Treatment
Phase I	$0.107	$0.176
Phase II	$0.217	$0.175
Phase III	NA	$0.175

Grower

	Control	Treatment
	$0.249	$0.255

Finisher

	Control	Treatment
	$0.335	$0.352
Total cost on average/pig/day:	$0.227	$0.227

Commericial Feed Costs

Nursery

	Control	Treatment
Phase I	$0.155	$0.262
Phase II	$0.307	$0.252
Phase III	NA	$0.276

Grower

	Control	Treatment
	$0.325	$0.334

Finisher

	Control	Treatment
	$0.418	$0.440
Total cost on average/pig/day	$0.301	$0.313

cost to feed a pig on either test diet was $0.227 per day. Even though feed intake was not significantly different, the extra feed that the control group consumed equalized the costs of the control group and the treatment group. On a commercial basis, the average cost to feed a pig from weaning to market weight in the control group was $.301 per day. The average cost on a commercial basis to feed a pig in the treatment group from weaning to market weight was $.313 per day. Since the cost to feed the pigs was the same in the control group and the treatment group on an ingredient basis, it is assumed that the complex diet sequence is less economical due to marketing or a higher cost to produce the feed. Cost was figured by the following equation: [(total feed consumed per diet for treatment group or control group)/(pig days for that diet period)]X(cost of the feed per kg) = cost/pig/day. The average of the different diets was then taken, giving the overall average feed cost per pig per day. If a producer farrows 10,000 market hogs a year, the complex diet sequence in the nursery would cost him approximately $16,000 more to feed than the simple diet sequence in the nursery. This figure is based on 10,000 hogs being marketed at 180 days of age (weaned at 20 days). However, by feeding the simple diet, that same producer would lose approximately $30,400 in lost pigs. This figure is based on the difference in mortality rate between the control group and the treatment group. There was a 4% higher mortality rate in the control group in the nursery. Therefore, hypothetically, 400 more pigs would die in the control group than in the treatment group during the nursery phase. There was a 3% higher mortality rate in the control group in the grower.

This would hypothetically mean that 288 of the remaining 9,600 pigs would die during the grower phase. The economic impact due to mortality would fluctuate with market prices. The prices that were used to figure the $30,400 loss were $40 for pigs in the nursery and $50 for pigs in the grower. Finisher losses were not calculated since the mortality rate was the same for both the treatment group and the control group. The higher feed cost per pig per day associated with the complex diet sequence is justified because it decreases mortality rates in the nursery phase and the grower phase. This decrease in mortality saves the producer more money than if he/she would feed a simple diet sequence in the nursery.

Implications

Feeding pigs a complex diet sequence in the nursery allows pigs to gain more during the first two weeks, post weaning. However, it does not significantly improve the pig's average daily gain or feed efficiency over a long period of time. Pigs fed a simple diet sequence in the nursery phase tended to overcome their slow start. However, mortality tended to be higher in the control group. It is not known if the mortality rates are directly associated with the nursery diet sequence fed. On an ingredient basis, there is no cost advantage of feeding one diet sequence over the other. However, at a commercial price, the complex diet sequence costs slightly more. Based on the results of this study, it is recommended that a complex diet sequence be fed to pigs during the nursery phase to lower mortality, while remaining economical.

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